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Whole Grain Gluten-Free Vegetable Savory Snacks

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Abstract

Gluten-free savory snacks were formulated and evaluated to offer nutritious treats for all and healthy option for gluten intolerance individuals. Four kinds of savory snacks (gluten-free, whole grains with fresh vegetables, low in fat and salt) were developed using base formulation (BF) of brown rice flour (45%), sorghum flour (20%), tapioca flour (7%), mashed potato (8%), canola oil (6%), guar gum (2%), baking powder (1.5%) and salt (0.5%). Fresh vegetables (carrots, broccoli, spinach, and red onion) were chopped and mixed with the base formulation (1:1). Chopped fresh garlic (5%) was added to carrot, broccoli and spinach (base-vegetable mix, BFV). Snack dough was prepared using 100 mL water per 100 g BFV. Two portions of snack dough (about 10 g each) were placed on the preheated KrumKake Baker and cooked for 2 minutes. Sixty two in-house volunteers judged Broccoli-Garlic snacks as significantly ($p \leq 0.05$) better in color/appearance than Carrot-Garlic, Spinach-Garlic and Red Onion savory snacks. A 30 g serving of these low salt, low fat healthy snacks would provide 5-7% of daily recommended dose of dietary fiber and potassium. This is the first report of developed whole grain gluten-free, 50% vegetable snacks. Texture and water activity of the developed snacks suggests the crispiness and potential long shelf stability. Tasters judged Carrot-Garlic (88%), Broccoli-Garlic (77%), Spinach-Garlic (68%) and Red Onion (65%) acceptable. Data suggest that the acceptability of gluten-free whole grain vegetable savory snacks is very encouraging and offers healthy alternative for all and especially for those sensitive to gluten.

Keywords: brown rice, gluten-free, snacks, sorghum, vegetables, whole grain

1. Introduction

Snacks play a significant role in family as well as public events. For children, snacks are extremely essential in school and in after school programs. Serving healthy snacks is important in providing good nutrition, supporting lifelong healthy eating habits, and helps to prevent costly and potentially-disabling diseases, such as heart disease, cancer, diabetes, high blood pressure, and obesity. Nutrition Policy and Promotion; Dietary Guidelines for Americans (USDA, 2010), recommends that, at least ½ of all the grains eaten should be whole grains. It is recommended that whole grains should be used in making food products rather than refined grains. The Whole Grain Council (Whole Grain Council, 2009) has summarized the scientific studies of the health benefits of whole grains. It has been documented that eating whole grains instead of refined grains lowers the risk of many chronic diseases. While benefits are most pronounced for those consuming at least 3 servings daily, some studies show reduced risks from as little as one serving daily. US Food and Drug Administration (Food and Drug Administration) allows label health claim for food containing 51% whole grains and 11 g of dietary fiber. Wheat is the main grain of many snack products, however there is increasing evidence of hyper-sensitivity to gluten in the celiac patients. Snacks made of gluten-free whole grains would be desirable. USDA food plate recommends that more than ¼ of the food plate should be vegetables (USDA, 2010). Recommended amounts of daily consumption of green leafy vegetables is two cups. Since most individuals and especially children do not meet the recommended intake of whole grains and/or vegetables. The development of whole grains and vegetable snacks would help to meet such a need. Gluten-free foods from whole grains are gaining popularity not only among the gluten-sensitive individuals (with celiac disease) but also among the general public who are becoming more aware of the health benefits from consuming gluten-free products. The quality of food produced on US farms is one of the best in the world. Proportion of income spent on food in US is the lowest in the world (US 7%, United Kingdom 9% and France 14%). However, food and snacks available in US are essentially unhealthy and contain high fat, high salt and high simple sugars (Mother-Jones, 2012). Consumers need to be educated to desire healthy home cooking or healthy promoting commercially produced foods and snacks. There are many studies reporting gluten-free breads with the addition of various hydrocolloids and leavening agents to match the characteristics of the gluten containing breads (Crockett et al., 2011; Hera et al., 2014; Sabanis et al., 2011; Schober et al., 2007). Gluten-free breads and cookies made with raw and popped amaranth flour were reported to be acceptable (Barca et al., 2010). Gluten-free flat breads and pasta of whole grains (corn, brown rice, sorghum, millet) without the addition of any chemical or eggs were reported with acceptability of 48-84% by the sensory evaluators (Kahlon et al., 2012, 2013a, 2013b). There was no citation found of whole grain gluten-free vegetable snacks. There is a need to develop gluten-free whole grain vegetable healthy snacks that would be high in dietary fiber, low in salt, fat and calories that could be prepared in any home and/or by commercial food companies. In the study reported herein, sixty two in house volunteers evaluated four kinds of snacks containing gluten- free whole grains (Brown Rice and Sorghum) and fresh vegetables (Carrot, Broccoli, Spinach, Red Onion and Garlic).

2. Materials and Methods

2.1 Preparation

Whole-grain brown rice, sorghum flour, fresh vegetables and other ingredients were purchased from local grocery stores. Brown rice flour was obtained by pin-milling these whole grains (160Z, Alpine Pin Mill, Augsburg, Germany). The composition of the ingredients is listed in Table 1. Brown rice and sorghum samples were analyzed by means of an elemental analyzer (Virio Macro, Elementar Analysen Systeme GmbH), nitrogen, according to AOAC method 990.03 (2000); total dietary fiber was determined according to AOAC method 985.29 (2000), crude fat with petroleum ether and an accelerated solvent extractor (ASE 350, Dionex Corp. Sunnyvale, CA); ash, according to AOAC method 942.05 (1990); and moisture, according to AOAC method 935.29 (1990).

Table 1. Ingredient composition of the gluten-free whole grain vegetable snacks dry matter (DM) basis, %

Ingredients	Protein	Fat	Minerals	Carbohydrate	TDF	DM
Brown Rice	9.04	7.24	1.1	82.62	3.08	88.94
Sorghum	8.63	3.44	1.45	86.48	6.63	90.67
Tapioca flour	---	---	---	100	---	96.15
Potato Flakes	8.34	0.41	1.45	81.17	6.6	93.42
Carrots, fresh	0.93	0.24	0.47	9.58	2.8	11.71
Broccoli, fresh	2.82	0.37	0.48	6.64	2.6	10.7
Spinach, fresh	2.86	0.39	0.87	3.63	2.2	8.6
Red Onion, fresh	1.1	0.1	0.22	9.34	1.7	10.89
Garlic, fresh	6.36	0.5	0.78	33.06	2.1	41.42

Brown Rice and Sorghum were analyzed for nitrogen by AOAC (1990, 2000). Nitrogen to protein factors used were brown rice 5.95 and sorghum 6.25 (AOAC, 2010). Total Dietary Fiber, TDF; Dry matter, DM. Carbohydrate = [100 – (Protein + fat + Ash)].

Tapioca flour data from product label.

Vegetables values from USDA Nutrient data base (http://ndb.nal.usda.gov/ndb/search/list).

2.2 Formulation

The gluten-free whole grains vegetable snacks were formulated using base formulation and fresh vegetables (1:1) as is basis. Composition of base formulation is given in Table 2. Fresh vegetables used were carrot, broccoli, spinach, red onion and garlic. Composition of the whole grain gluten-free vegetable snacks is given in Table 3. Snack dough was prepared by mixing ingredients in a KitchenAid table top mixer (KitchenAid Proline, St. Joseph, MI). Snack dough was covered and held at room temperature for 30 min. Krumkake Baker was heated till ready light turned off at 230 ºC, baking temperature ranged from 220 -230 ºC as measured by Anritsu Meter AP-710 (Anritsu meter Co., Tokyo, Japan). Two equal portions of snack dough (about 10 g each) were cooked for two minutes in 800 watts double 5 inch Krumkake Baker (Vitantonio, Eastlake, OH). Fresh baked whole grain gluten-free low salt, low fat vegetable snacks were cooled to room temperature (Figure 1). Cooled snacks were sealed in vacuum food saver packages by Food Saver 2200 Series (FoodSaver, Boca Raton, FL).

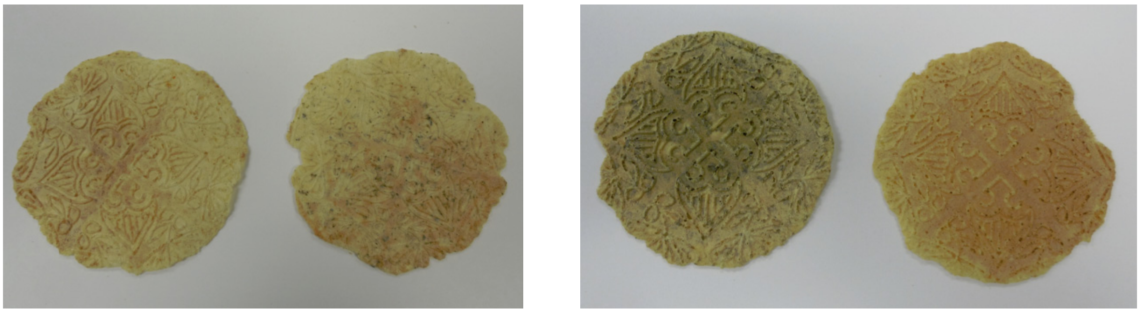

Figure 1. Developed vegetable savory snacks (left to rights) carrot-garlic, broccoli-garlic, spinach-garlic and red onion

Table 2. Base mix of savory gluten-free snacks (as is basis)

Ingredients	%
Brown Rice flour	45
Sorghum flour	20
Tapioca flour	17
Mashed Potato	8
Canola Oil	6
Guar gum	2
Baking powder	1.5
Salt	0.5
Total	100

Table 3. Composition of savory gluten-free vegetable snacks

Snack	Base Mix, g	Vegetable, g	Garlic, g	Water, mL
Carrot-Garlic	100	100	10	200
Broccoli-Garlic	100	100	10	200
Spinach-Garlic	100	100	10	200
Red Onion	100	100	---	200

All the vegetables and garlic were fresh, chopped.

2.3 Sensory Acceptance of Vegetable Snacks

A total of 62 people were selected voluntarily for analysis of acceptance of developed vegetable snacks. In the individual booths with white light tasters were offered all four appropriately labeled samples of savory snacks in a tray. A five-point hedonic scale ranging from 1 to 5 was provided to selected consumers to indicate sensory judgment of "disliked very much" (1 point) to "liked very much" (5 points), with a central hedonic point which indicated "neither liked nor disliked" (3 points). A two pint scale, indicating that developed product was acceptable (2) or not acceptable (1) was used to determine the overall acceptance of samples. The attributes of color (appearance), odor and aroma, taste and flavor and texture (mouth feel) were assessed in all samples. The Desirability Evaluation Index of the developed snacks was calculated as (Like Very much + Like slightly + Neutral/2) % (Kahlon et al., 2013a, 2013b).

2.4 Water Activity

Water activity (Aw) was measured at 25.01 ± 0.02 ºC by triplicate using an AquaLab dew point water activity meter 4TE (Decagon Devices, Inc., Pullman, WA).

2.5 Texture

Compression tests were done on 55 mm diameter flat snacks mounted between two 3.5 × 3.5 inch square, ¼ in thick, iron plates with 1 in diameter centered holes and puncturing over smooth and sound snack surfaces with 1.14 ± 0.17 mm thickness with a flat 3 mm diameter cylindrical probe attached to a TA-XT2i Texture Analyzer (Texture Technologies Corp., Scarsdale, NY) set at 1 mm/s test speed and 2 mm rupture test distance. Temperature during testing was 18.7 ± 0.3 °C and samples were tested right after opening vacuum sealed plastic bags used for packaging the snacks. Number of cracks, force needed for first crack, first crack area, maximum force and maximum force area were obtained by 10 replicates for each snack. Gram force (g-f) values were converted into newtons (N); (1 newton [N] = 101.971621297793 gram-force [gf]).

2.6 Density

The bulk density (ρ_b) was obtained by triplicate from round flat snacks using an analytical balance and measuring the diameter and maximum and minimum thickness in five random places with a digital micrometer. True density (ρ_t) was determined using an AccPyc II 1340 gas pycnometer (Micromeritics Instrument Co., Norcross, GA) at 21.4 ± 0.4 ºC. Samples of each snack were cut into small pieces and dried at room temperature for 15 h at 0% relative humidity in a vacuum desiccator with anhydrous calcium sulfate (W. A. Hammond Drierite, Xenia, OH). After drying, samples were compressed into a measuring cylinder for five true density measurements.

Where: ρ_t = true density; ρ_b = bulk density.

2.7 Statistical Analysis

Data were analyzed with Minitab statistical software (version 14.12.0, Minitab Inc., State College, PA) by one-way analysis of variance and Tukey's multiple comparison tests with ($P \leq 0.05$) as criteria of significance.

3. Results and Discussion

In house volunteer tasters (N=62) judged Broccoli-Garlic snacks as significantly ($P \leq 0.05$) superior for Color/Appearance than Spinach-Garlic snacks (Table 4).

Table 4. Results of taste panel of brown rice – sorghum whole grain (gluten-free), vegetable, low salt savory snacks[xyz]

Gluten free Vetable Snacks	Color/Appearance	Odor/Aroma	Taste/Flavor	Texture/Mouth feel	Acceptanc
Carrot-Garlic	4.00 ± 0.11^{ab}	3.53 ± 0.09^{b}	3.61 ± 0.12^{a}	4.19 ± 0.10^{a}	1.85 ± 0.05^{a}
Broccoli-Garlic	4.21 ± 0.10^{a}	3.31 ± 0.11^{b}	3.45 ± 0.14^{a}	3.87 ± 0.12^{a}	1.74 ± 0.06^{ab}
Spinach-Garlic	3.86 ± 0.14^{b}	3.31 ± 0.10^{b}	3.24 ± 0.15^{a}	3.89 ± 0.12^{a}	1.66 ± 0.06^{b}
Red Onion	3.90 ± 0.12^{ab}	3.92 ± 0.11^{a}	3.27 ± 0.13^{a}	2.82 ± 0.13^{b}	1.63 ± 0.06^{b}

[x]Values are mean±SEM; n = 62.

[y]Color/Appearance, Odor/Aroma, Taste/Flavor and Texture/ Mouth feel were on a scale of 1-5 (Like very much = 5, like slightly = 4, neutral = 3, dislike slightly = 2 and dislike very much = 1); Acceptance was on scale of 1-2 (Acceptable = 2 and unacceptable = 1).

[z]Values within columns with different superscript letters differ significantly ($P \leq 0.05$).

Color/Appearance of Carrot-Garlic and Red Onion snacks were similar to that of Broccoli-Garlic and Spinach-Garlic snacks. The broccoli snacks maintained green color after cooking which was preferred by the tasters, over charcoal brown color of cooked spinach snacks. Odor/Aroma of Red-Onion snacks was judged to be significantly preferred to that of other three snacks tested. Taste/Flavor was judged to be similar for all the four kinds of snacks tested. Texture/Mouth feel of the Carrot-Garlic, Broccoli-Garlic and Spinach-Garlic snacks were similar and significantly higher than that of Red Onion snacks. Panelist acceptance % of Savory snacks was Carrot-Garlic, Broccoli-Garlic, Spinach-Garlic and Red Onion) snacks are shown (Figure 2).

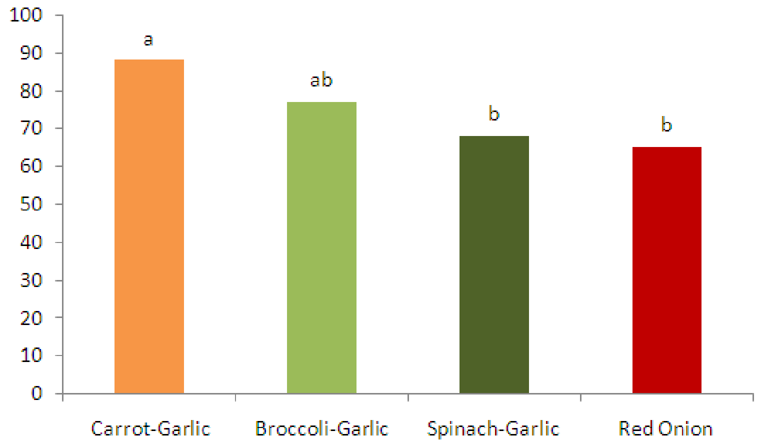

Figure 2. Panelist acceptance % for developed whole grain, gluten-free vegetable, Carrot-Garlic mixture, Broccoli-Garlic mixture, Spinach-Garlic mixture and Red Onion snacks

Bars with different letters differ significantly ($P \leq 0.05$).

Acceptance of Carrot-Garlic snacks was significantly higher than Spinach-Garlic and Red-Onion snacks. Acceptance of Broccoli-Garlic snacks was similar to other snacks tested. Acceptance % for various snacks tested was Carrot-Garlic 88%, Broccoli-Garlic 77%, Spinach-Garlic 68% and Red Onion 65%. Data suggest that 65-88% acceptance would be considered encouraging, which is quite similar to (77-79%) acceptance observed for brown rice and sorghum flour flat breads and pasta (Kahlon et al., 2012, 2013a). However the acceptance of snacks reported herein is much higher than (48%) reported for sorghum-garbanzo high protein pasta (Kahlon et al., 2013b). Acceptable functionality of amaranth cookies were reported (Barca et al., 2010), however no sensory evaluation data was shown to have valid comparison with the gluten-free vegetable snacks reported herein. This is the first report of whole grain gluten-free vegetable health promoting snacks which could be made in any house kitchen and/or commercial production.

Desirability Index determined as (Like Very much + Like Slightly + Neutral/2), % for Carrot-Garlic, Broccoli-garlic, Spinach-Garlic and Red Onion determined to be for Color/Appearance (85%, 91%, 79%, 83%), Odor/Aroma (73%, 64%, 62%, 83%), Taste/Flavor (77%, 69%, 60%, 60%), Texture/Mouth feel (90%, 83% 60%, 42%), respectively (Kahlon et al., 2013a, 2013b). The desirability indexes for various sensory parameters for Carrot-Garlic, Broccoli-Garlic and Spinach-Garlic snacks ranged 60-91% which could be considered very encouraging. Texture/Mouth feel desirability index for Red Onion snacks was only 42% which needs improvement to be acceptable.

Water activity

Water activity (Aw) of Carrot-Garlic and Spinach-Garlic snacks was significantly lower than that for Broccoli-Garlic and Red Onion snacks (Table 5). Data suggest that Carrot-Garlic and Spinach-Garlic snacks would have higher shelf life. Aw of the vegetable snacks tested varied from 0.2 to 0.3. These Aw values are typical of very crispy snacks. Previously Aw of 0.44 for carrot snacks have been reported with desired microbiological stability (Adams et al., 1997). Similar Aw of 0.44 had shown improves crispness (Dueik et al., 2013).

Texture

Texture of Carrot-Garlic, Spinach-Garlic and Red Onion was similar and significantly higher than Broccoli-Garlic snacks (Table 5). Data suggest that Carrot-Garlic, Spinach-Garlic and Red Onion were crispier than Broccoli-Garlic snacks as less force (N) was required to break broccoli snacks.

Density

True density (ρ_t) of Spinach-Garlic and Red Onion snacks was significantly higher than that for Carrot-Garlic and Broccoli-Garlic snacks (Table 5). However, the density difference among the gluten-free vegetable snacks tested was very small (1.385-1.397).

Table 5. Water activity, texture and density of brown rice – sorghum whole grain (gluten-free), vegetable, low salt savory snacks[xy]

Gluten-free Vegetable Snacks	Water Activity	Texture, N	Density, ρ_t
Carrot-Garlic	0.232±0.006[b]	4.196±0.294[a]	1.385±0.001[b]
Broccoli-Garlic	0.298±0.006[a]	2.851±0.384[b]	1.386±0.003[b]
Spinach-Garlic	0.207±0.009[b]	4.100±0.368[a]	1.393±0.001[a]
Red Onion	0.283±0.004[a]	4.430±0.421[a]	1.397±0.001[a]

[x]Values are mean±SEM; Values are mean of triplicate analysis for water activity (n=3), texture (n=10) and density (n=5).

[y]Values within columns with different superscript letters differ significantly ($P \leq 0.05$).

4. Conclusion

This is the first scientific report of developed whole grain gluten-free vegetable healthy low salt, low fat snacks. These snacks can be prepared in any house kitchen and/or commercial production. Texture and water activity of the developed snacks suggests the crispness and potential long shelf stability. These chips contain 33-50% less salt than most chips available in the market. A 30 g serving of these low salt, low fat healthy snacks would provide 5-7% of daily recommended dose dietary fiber and potassium. Acceptability of whole grain gluten-free vegetable snacks by in house volunteers (n=62) was 65-88%.

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